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Outcomes of cholera and measles outbreak alerts in the Democratic Republic of Congo

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Setting: In 1995, a rapid response project for humanitarian and medical emergencies, including outbreak responses, named '*Pool d'Urgence Congo*' (PUC), was implemented in the Democratic Republic of Congo by Médecins Sans Frontières.

Objective: To assess the outcomes of cholera and measles outbreak alerts that were received in the PUC surveillance system between 2016 and 2018.

Design: This was a retrospective cross-sectional study.

Results: Overall, 459 outbreak alerts were detected, respectively 69% and 31% for cholera and measles. Of these, 32% were actively detected and 68% passively detected. Most alerts (90%) required no intervention and 10% of alerts had an intervention. There were 25% investigations that were not carried out despite thresholds being met; 17% interventions were not performed, the main reported reason being PUC operational capacity was exceeded. Confirmed cholera and measles outbreaks that met an investigation threshold comprised respectively 90% and 76% of alerts; 59% of measles investigations were followed by a delayed outbreak response of ⩾14 days (n = 10 outbreaks).

Conclusion: Some alerts for cholera and measles outbreaks that were detected in the PUC system did not lead to a response even when required; the main reported reason was limited operational capacity to respond to all of them.

Surveillance is a major component of any health system that aims to deliver comprehensive and effective services for its populations.[1] Surveillance implies that there is a continuous systematic collection, analysis and interpretation of health-related data for decision making.[2] Information that is generated by the surveillance system must therefore be of good quality to ensure prompt and accurate responses to any health concerns that arise.[3,4]

Although recommended in all aspects of healthcare, the role of surveillance in the management of infectious epidemic-prone diseases is particularly critical in ensuring these diseases are detected early so that onward transmission of infection is prevented.[5] Unfortunately, in many low- and middle-income countries, implementation of good surveillance systems is limited by challenges that include shortages or non-availability of resources and inefficient coordination between national, intermediate and peripheral levels.[6]

In the Democratic Republic of Congo (DRC), a national surveillance system that monitors 17 potential epidemic diseases through weekly reporting of outbreak-related information from peripheral levels to the central unit has been in place since 1985. However, the national surveillance system does not fully cover rural settings, and there are sometimes substantial delays in the reporting process, leading to late detection of outbreaks and subsequent delayed responses.[7,8]

Given the weakness of the existing surveillance system and the need for timely health information, a project named the '*Pool d'Urgence Congo*' (PUC) was implemented by Médecins Sans Frontières Operational Centre Brussels (MSF OCB) in 1995. The PUC project aims to respond rapidly to humanitarian and medical emergencies in the DRC. Surveillance is conducted for seven diseases—cholera, measles, typhoid fever, yellow fever, Ebola virus disease, malaria and meningitis. The PUC system comprises three components: 1) sentinel sites based in the provinces, 2) a mobile intervention team, and 3) a coordination team based in Kinshasa, DRC.[7] The sentinel sites detect outbreak alerts from the national surveillance system, either through proactive calls to the health district office and to the community (called 'active detection') or after receiving data from the Ministry of Health (MOH) (called 'passive detection'). These alerts are sent from the sentinel site to the coordination team in Kinshasa over 3 days through an electronic MS Access database (MicroSoft, Redmond, WA, USA) using email and the data are analysed: if selected criteria (thresholds) pertaining to the outbreak are fulfilled, an investigation then follows. If there is confirmation (or not) of an outbreak, an intervention by the mobile team is rapidly mobilised.[7]

Anecdotally, a number of outbreak alerts sent through to the coordination team were not investigated despite fulfilling the investigation criteria, and among outbreaks where intervention criteria were met, subsequent interventions were not carried out. These observations made clear that an assessment of the PUC surveillance system would be useful to inform recommendations on how to improve the alert and response. This is also important because considerable resources are often mobilised to conduct an outbreak investigation and this may be wasteful if no subsequent interventions take place.

We therefore aimed to assess the outcomes of cholera and measles outbreak alerts that were detected in the PUC surveillance system; these represented 80% of all PUC intervention alerts from 2016 to 2018. Specific objectives were to determine 1) the number (propor-

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tion) of alerts that were actively or passively detected, met eligibility criteria for investigation/intervention and subsequently had an investigation/intervention done; 2) the number (proportion) of alerts that did not meet the eligibility criteria and reasons for not carrying out an investigation/intervention; 3) the number (proportion) of alerts with biological confirmation of passing the investigation threshold; and 4) time from alert to investigation and outbreak response.

METHODS

Study design

An analytical cross-sectional study using routinely collected data from the PUC system was conducted.

Settings

General setting

The DRC, a central African country (area 2345 km^2; population 85 million),[9] experiences infectious disease outbreaks such as cholera, measles, Ebola and yellow fever every year. Several factors contribute to the occurrence of these outbreaks, including the country's ecosystem characteristics, health policy and management, socio-economic factors and political instability.

Specific setting: PUC intervention areas

The PUC intervention zone covers up to 18 of 26 provinces in DRC, representing 69% coverage at the national level (Figure 1). Overall, 344/517 (67%) health districts in the country are in the PUC intervention zone. The high frequency of the outbreaks in these areas, as well as limited access and poor local response capacity, are some of the reasons for implementing PUC in these parts of the country. There are six sentinel sites that provide services in these areas. The integrated disease surveillance and response system is implemented in PUC intervention areas in collaboration with the MOH and has the capacity to simultaneously conduct two interventions and one investigation.

PUC project

In each of the six sentinel sites, three persons are involved in the detection of alerts; two are skilled in epidemiological surveillance and one is a logistician. After detecting an alert, they are requested to provide a report to the coordination team within a maximum period of 24 hours. The coordination team assesses the relevance of the alert and gives feedback to the sentinel sites. When the threshold for an investigation is reached, this is validated and an investigation is carried out by the mobile intervention team and a strategic decision is made and submitted to the coordination team for validation. For cholera and measles outbreaks, the goal of the project is to carry out an intervention in <14 days after validation (Supplementary Figure S1).[7] Diagnostic criteria for the alert, the investigation and intervention thresholds, including biological confirmation,[10,11] that are used in the PUC surveillance system for both outbreaks are described in Supplementary Table S1.[8,10,11]

The interventions are always adapted to the epidemiological context for measles and cholera. Thus, for example, full interventions are used in case of large-scale epidemics and 'lightning interventions' for isolated epidemics.

Study population

All cholera and measles alerts that were received by the six sentinel sites in the 18 DRC provinces between 1 January 2016 and 31 December 2018 were included.

Data variables, sources of data and validation

Data variables included disease type (cholera/measles), number of alerts, type of detection (active/passive), respective investigation and intervention outcomes, validation date of the investigation, investigation status, start and end date of the investigation, validation date of the intervention, intervention status, start date of the intervention, biological confirmation and reasons for lack of investigation/intervention.

Data were exported from the Microsoft Access coordination PUC system database into an Excel file (Microsoft), followed by cross-checking and validation using data from Excel file databases available at sentinel sites.

Data analysis and statistics

Data were entered into EpiData Entry client v4.6.0.0. (Epidata Association, Odense, Denmark) software and analysed using R v3.6.1 software (R Foundation for Statistical Computing, Vienna, Austria). Categorical variables were described using frequencies and percentages; continuous variables were analysed and reported using means and standard deviations (±SDs).

Ethics approval

The study was approved by the *Comité National d'Ethique de la Santé*, Kinshasa, DRC (Approval number: 119/CNES/BN/PMFF/2019). Exemption was obtained from the Ethics Advisory Group of the International Union against Tuberculosis and Lung Disease, Paris, France (EAG number: 35/19) since this research fulfilled the exemption criteria set by the MSF Ethics Review Board for a posteriori analyses of routinely collected clinical data and thus did not require MSF ERB review. It was conducted with permission from the Medical Director of the MSF Operational Centre Brussels.

RESULTS

From 2016 to 2018, 459 alerts of these two diseases were detected in the PUC surveillance system—315 (69%) for cholera and 144 (31%) for measles. For both diseases, 148 (32%) were through active detection, while 311 (68%) were through passive detection.

Among actively detected alerts, the investigation threshold was met in 88 (59%) outbreaks, which were followed by investigations in 42 (28%) outbreaks. The intervention threshold was reached in 37 (25%) outbreaks and 19 (13%) had an outbreak response that was carried out. There were two alerts that had an intervention conducted without a previous investigation, which had already been carried out by a partner organisation.

Among passively detected alerts, the investigation threshold was met in 140 (45%) outbreaks, which were

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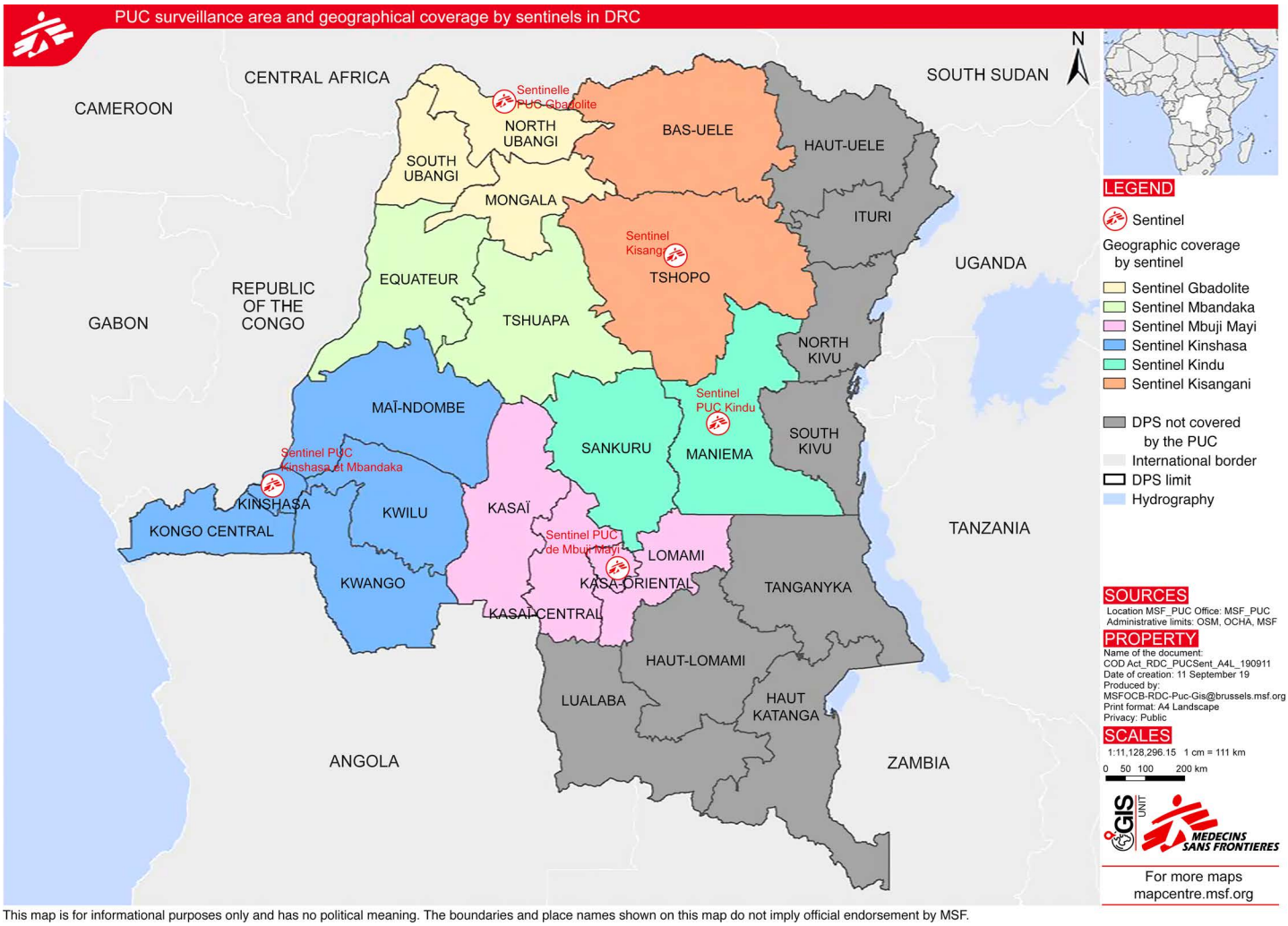

FIGURE 1 *Pool d'Urgence Congo* surveillance area and geographical coverage by sentinel sites, Democratic Republic of Congo.

followed by investigations in 72 (23%) outbreaks. The intervention threshold was reached in 53 (17%) outbreaks and 25 (28%) had an outbreak response carried out. Once again, and for similar reasons, two alerts had an intervention without a previous investigation.

Overall, 21 (14%) actively detected alerts and 27 (9%) passively detected led to interventions; 411 (90%) alerts that were detected in the PUC system did not require or could not get an outbreak response. Irrespective of the type of detection, and despite the thresholds being met, a total of 114 (25%) investigations were not carried and 77 (17%) interventions were not validated (Figure 2).

Biological confirmation status was assessed in the PUC surveillance zone either by PUC or MOH in 218 (69%) and 133 (92%) of cholera and measles outbreak alerts, respectively. Of the 112 confirmed cholera outbreak alerts, 101 (90%) met the investigation threshold. Of the confirmed 99 measles outbreaks alerts, 75 (76%) met the investigation threshold.

The main reason for not performing investigations and outbreak responses for both diseases was inadequate PUC operational capacity (Table 1A and 1B). In case of cholera, reactivity time from investigation to intervention in areas covered by the PUC system was acceptable, except for investigations that lasted >14 days for three (5%) alerts (Table 2A). In case of measles, there was a delay of >14 days between the end of the investigation and the start date of the intervention in 10/17 (59%) alerts (Table 2B).

DISCUSSION

This is the first study to assess outcomes of alerts detected in the MSF PUC surveillance system in the DRC. Study strengths were the inclusion of all 18 provinces covered by the PUC surveillance system; as all the outbreak alerts were included, sampling was not required. We also focused on the two diseases responsible for the majority (80%) of outbreaks in the country and that required interventions by the PUC system. Hence, findings from the study can be generalised to the outcomes of all the alerts that are received for both diseases in the system. The study was conducted in accordance with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.[12]

The study had some limitations. First, the study's retrospective nature meant that some data, such as some unrecorded validation and investigation dates, were missing. Second, some detected alerts within the PUC system were not biologically confirmed due to logistic challenges such as lack of materials for sample collection at the peripheral health centres, transportation issues or shortages in the supply of reagents even at the national level.

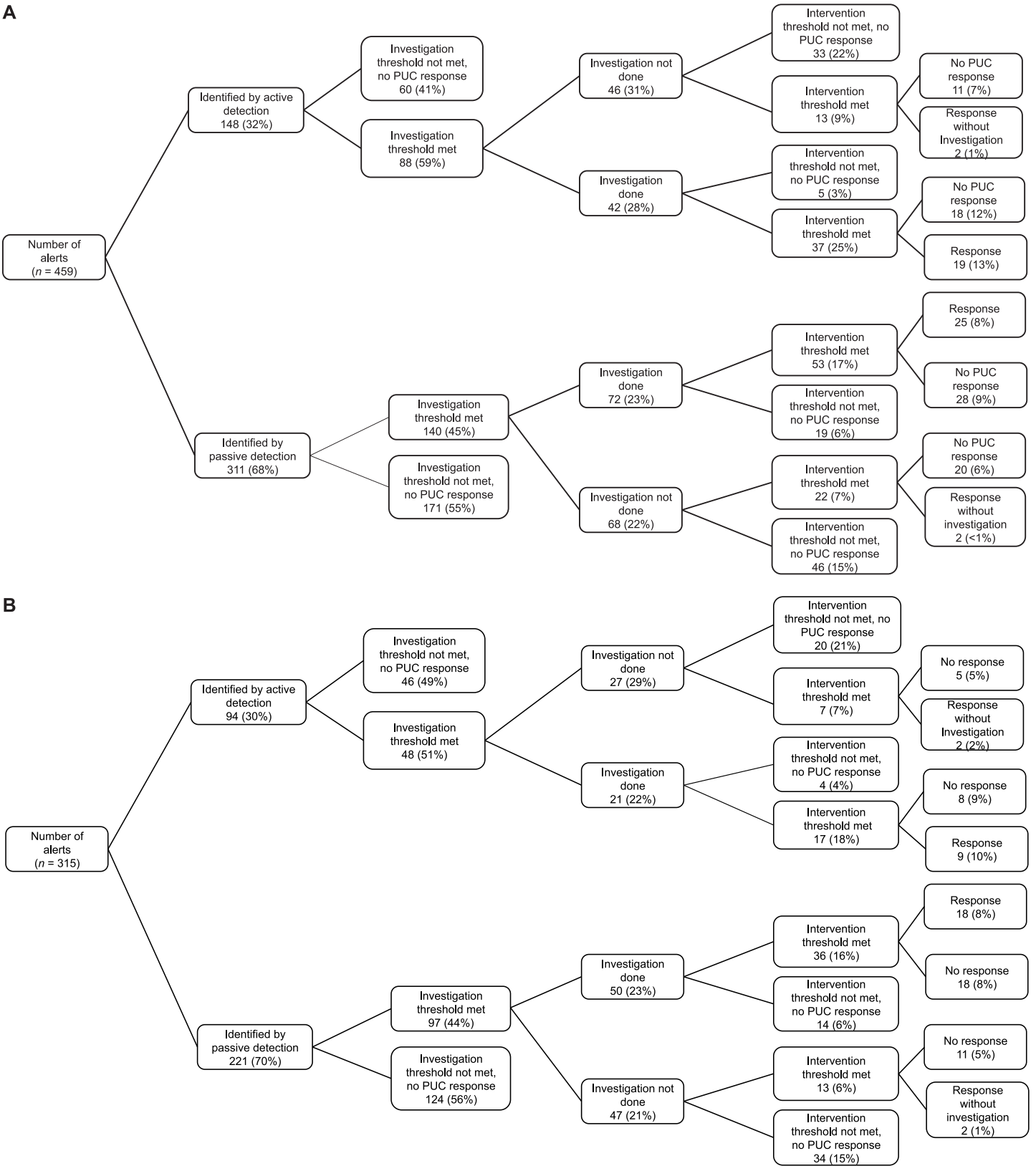

FIGURE 2 **A)** Total number of measles and cholera alerts received, types of detection and their outcomes in 18 provinces under the PUC Project, DRC, 2016–2018. **B)** Number of cholera alerts received, types of detection and their outcomes in 18 provinces under the PUC Project, DRC, 2016–2018.

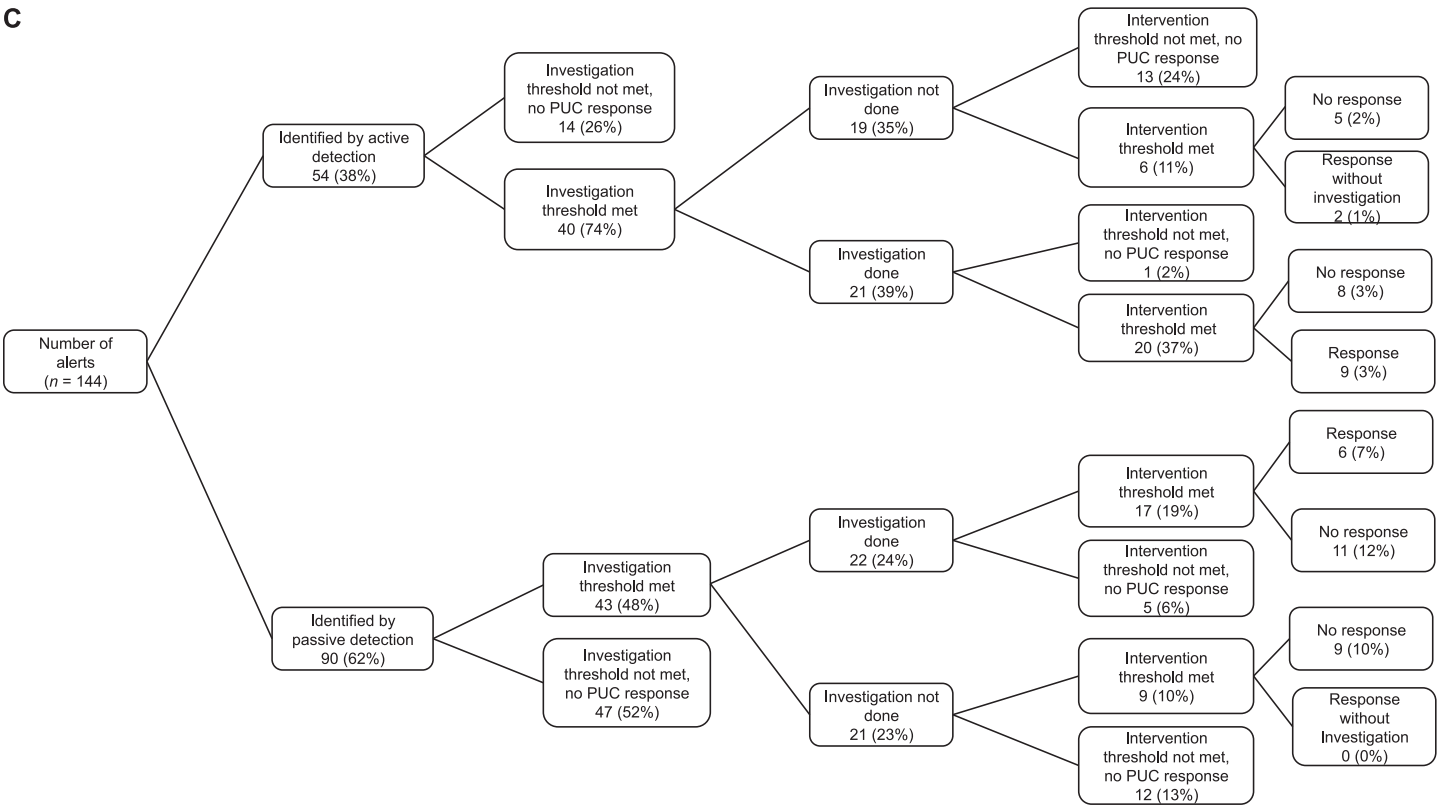

FIGURE 2 **C)** Number of measles alerts received, types of detection and their outcomes in 18 provinces under the PUC Project, DRC, 2016–2018. PUC = Pool d'Urgence Congo; DRC = Democratic Republic of Congo.

Despite these limitations, there were some important findings that merit consideration. First, the proportion of actively detected alerts represented approximately one third of the total number of alerts detected in the system. There are some possible explanations for these findings. In 2005, the PUC project implemented proactive calls to detect disease outbreaks in order to improve timeliness and completeness of data from the national epidemiological surveillance system. However, later on in 2016, proactive calls were reduced after capacity-building training courses were provided to train health workers to improve reporting of suspected cases to the MOH and MSF and to reduce excessive costs caused by the calls. This probably resulted in an increase in pas-

TABLE 1 Reasons for not initiating investigations and interventions although required in 18 provinces under the PUC surveillance system, DRC, 2016–2018

A) Cholera	*n*	(%)*	B) Measles	*n*	(%)
No investigation although required, *n*	74		No investigation although required, *n*	40	
PUC operational capacity reached	49	(62)	PUC operational capacity reached	26	(65)
Presence of another partner organisation	39	(53)	Low lethality (<1%)	23	(56)
No increase in number of cases	25	(34)	No increase in number of cases	20	(50)
Efficient local capacity to response	8	(11)	Presence of another partner	17	(43)
Low lethality (<1%)	7	(9)	Efficient local capacity to response	1	(3)
Difficult geographical accessibility	2	(3)	Insecurity	1	(3)
Delay at the decision tree following the chain of communication	1	(1)	No outbreak response although required, *n*	35	
No intervention although required, *n*	42		PUC operational capacity reached	29	(83)
PUC operational capacity reached	35	(83)	Presence of another partner	26	(74)
Presence of another partner organisation	24	(57)	Efficient local capacity to response	5	(14)
No increase in number of cases	7	(17)	Low lethality (<1%)	4	(11)
Delay in the investigation	2	(5)	No increase in number of cases	2	(6)
Low lethality (<1%)	2	(5)	Difficult geographical accessibility	1	(3)
Efficient local capacity to response	1	(2)	Delay in the investigation	1	(3)

*There may be more than one reason.
PUC = Pool d'Urgence Congo; DRC = Democratic Republic of Congo.

TABLE 2 Reactivity time from alert investigation to intervention in 18 regions in DRC under the PUC surveillance system, 2016–2018

A) Cholera	Alerts requiring action	Alerts requiring action with registered dates	Time required: Mean ± SD (days)	Time required: Range (days)	Alerts with action undertaken in >14 days* *n* (%)
Investigation process					
Time from alert validation to investigation start	72	58	5 ± 5	0–19	NA
Duration of the investigation	72	66	5 ± 4	0–17	3 (5)
Intervention process					
Time from end of investigation to intervention start	31	21	3 ± 4	0–17	1 (3)

B) Measles	Alerts requiring action	Alerts requiring action with registered dates	Time required: Mean ± SD (days)	Time required: Range (days)	Alerts with action undertaken in >14 days* *n* (%)
Investigation process					
Time from alert validation to investigation start	43	42	6 ± 6	0–25	NA
Duration of the investigation	43	43	7 ± 4	0–16	2 (5)
Intervention process					
Time from end of investigation to intervention start	17	17	21 ± 25	0–101	10 (59)

*Maximum wait time recommended by the PUC surveillance system.
DRC = Democratic Republic of Congo; PUC = Pool d'Urgence Congo; SD = standard deviation; NA = not available.

sive detection of alerts, as reported in the study. Of note, a passive strategy has been adopted elsewhere, mostly in industrialised countries, where outbreaks are less likely to occur.[13] However, since the reporting of suspected cases to the MOH from the peripheral level is not yet optimal in terms of completeness and promptness for several reasons (including intermittent telephone and internet network services), we believe that both active and passive detection strategies should be maintained for a certain period of time to be more effective in detecting alerts and outbreaks.

The active strategy can also be improved. In one study from the Central African Republic, a positive experience of data transmission through a smartphone application was reported; this could improve completeness and timeliness of disease surveillance reports in the PUC system.[14] In another study from Madagascar, data collected by sentinel sites through short message services (SMS) were automatically analysed to detect malaria trends and outbreak alerts whilst automatic feedback was generated for decision-making and no internet use was required.[15] More recently, one study from Gabon reported on the advantages of syndromic surveillance.[16] There were also other experiences reported from industrialised countries using a semiparametric method.[17]

Second, inadequate PUC operational capacity was the main reason for the lack of investigation of measles and cholera alerts that met the pre-requisite criteria. Although the PUC had the capacity to respond to three simultaneous outbreaks during the study period, this was insufficient due to the high recurrence of epidemic outbreaks. This was expected as the PUC target areas cover 69% of a large country. A more thorough investigation is required to ensure that PUC operational capacity corresponds to requirements in areas with a high probability of the 17 epidemics under epidemiological surveillance. The operational capacity of the PUC during the study period was saturated by other emergencies, including Ebola, yellow fever and typhoid fever; advocacy efforts were thus put in place to mobilise other actors when the PUC operational capacity had reached its limits.

Third, while the majority of cholera alerts that were investigated based on the criteria used for this threshold led to a confirmation of the outbreak, the investigation threshold for measles still needs to be improved. It appears that there may be some inaccuracies in the additional criteria applied to this threshold, resulting in bias. For example, in the DRC, vaccine coverage in all health zones is largely overestimated due to population data inaccuracies since a general census has not been conducted for more than 30 years. Moreover, poor health care access and health-seeking behaviours in DRC are important factors leading to unrecorded community deaths and an underestimation of mortality data, one of the main criteria for the investigations; these should be reviewed in the future. Similarly, ensuring accurate interpretation of the selected criteria is vital.

Fourth, and contrary to the situation with cholera, response to measles outbreaks was slow, and mostly due to internal and external factors such as procedure validation, PUC operational capacity, accessibility issues, disruption in vaccine supply and difficulties encountered with local authorities. These issues need to be resolved to reduce morbidity and mortality due to this disease.

In conclusion, a tenth of the alerts in the PUC system led to a response. However, some did not even when required; the main reason reported was the limited operational capacity of the PUC to attend to all outbreaks that required further investigation.

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Contexte : En République Démocratique du Congo, un projet appelé « Pool d'Urgence Congo » (PUC) a été mis en œuvre depuis 1995 par Médecins Sans Frontières pour une réponse rapide aux urgences humanitaires et médicales, notamment les réponses aux flambées épidémiques.
Objectif : Evaluer les résultats d'alertes épidémiques choléra et rougeole qui ont été reçues par le système de surveillance PUC entre 2016 et 2018.
Schéma : Ceci est étude rétrospective transversale.
Résultats : Au total, 459 alertes épidémiques ont été détectées, 69% et 31% pour le choléra et la rougeole, respectivement. Parmi elles, 32% ont été activement détectées et 68% détectées passivement ; 90% des alertes n'ont pas nécessité d'intervention et 10% ont été suivies d'intervention. Il y a eu 25% d'investigations qui n'ont pas été réalisées alors que les seuils étaient atteints, et 17% des interventions n'ont pas été réalisées ; la principale raison invoquée était que la capacité opérationnelle du PUC était dépassée. Les flambées de choléra et de rougeole qui ont atteint le seuil d'investigation et ont été confirmées étaient de 90% et 76%, respectivement. Ont été suivies 59% des investigations relatives à la rougeole d'une réponse à la flambée retardée de ⩾14 jours (n = 10 flambées).
Conclusion : Dans le système PUC, certaines alertes relatives à des flambées de choléra et de rougeole qui ont été détectées n'ont pas abouti à une réponse qui était pourtant requise ; la raison principale invoquée était la capacité opérationnelle limitée pour répondre à toutes les alertes.

Marco de referencia: En la República Democrática del Congo, Médecins Sans Frontières introdujo desde 1995 un proyecto denominado '*Pool d'Urgence Congo*' (PUC) para dar una respuesta rápida a las urgencias humanitarias y médicas, incluida la respuesta a los brotes epidémicos.
Objetivo: Evaluar los resultados de las alertas de brotes de cólera y sarampión que recibió el sistema de vigilancia del PUC del 2016 al 2018.
Método: Fue un estudio transversal retrospectivo.
Resultados: En general, se detectaron 459 alertas de brotes, 69% por cólera y 31% por sarampión, de los cuales 32% por detección activa y 68% por detección pasiva; 90% de las alertas no precisaron ninguna intervención y en 10% se realizó una intervención. No se llevó a cabo un 25% de las investigaciones, pese a que se habían alcanzado los umbrales y 17% de las intervenciones no se realizaron; la principal causa referida fue la sobrecarga de la capacidad operativa del PUC. De las alertas confirmadas, alcanzaron el umbral de investigación el 90% de cólera y el 76% de sarampión. En 59% de las investigaciones de sarampión, una respuesta tardía al brote comenzó 14 días o más después de finalizar la investigación (n = 10 brotes).
Conclusión: En el sistema PUC, algunas alertas por brotes de cólera y sarampión que se detectaron no dieron lugar a una respuesta, aunque esta era necesaria; la principal razón invocada, fue la limitación de la capacidad operativa para responder a todas las alertas.

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